MBC Manned Space-craft Ctr

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OCT 29 1970

REPLY TO ATTN OF: GP

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U. S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code USI, the attached NASA-owned U. S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U. S. Patent No.	: 3,490,440
Government or Corporate Employee	: INSTITUTE OF RESEARCH AND INSTRUMENTATION
Supplementary Corporate Source (if applicable)	:
NASA Patent Case No.	: XMS-04212-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:
Yes [X] No [ ]
Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Elizabeth A. Carter

Elizabeth A. Carter
Enclosure
Copy of Patent cited above

FACILITY FORM 602

N71-12346 (ACCESSION NUMBER)	(THRU)
5 (PAGES)	00 (CODE)
(NASA CR OR TMX OR AD NUMBER)	03 (CATEGORY)

05

N71-12346

UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

BOULDER, COLORADO

Quarterly Status Report #24

For the Period 1 September 1970 to 30 November 1970

NASA Contract Number NSR 06-007-014

UCAR Project Number 9712

Flight Support:

Dr. Kenneth Frost of the Solar Physics Branch, Goddard Space Flight Center has not requested flight support during this reporting period.

An estimate of the balance of funds remaining in this contract is:

Total Contract Funds	\$74,000
Expenditures through 11/30/70	50,589
Commitments on 11/30/70	0
Balance of Funds Available	\$23,411

One (1) 10.6 x 10^6 ft^3 balloon made from 0.5 polyethylene is on hand at Palestine for a future flight for Dr. Frost. Additional balloons will be provided from NCAR stock as required.

Plans:

To provide flight support as requested.

Alvin L. Morris

Alvin L. Morris, Manager
Scientific Balloon Facility

N71-12346

Jan. 20, 1970 B. MOSIER ET AL 3,490,440

PRESSED DISC TYPE SENSING ELECTRODES WITH ION-SCREENING MEANS

Filed Jan. 5, 1967

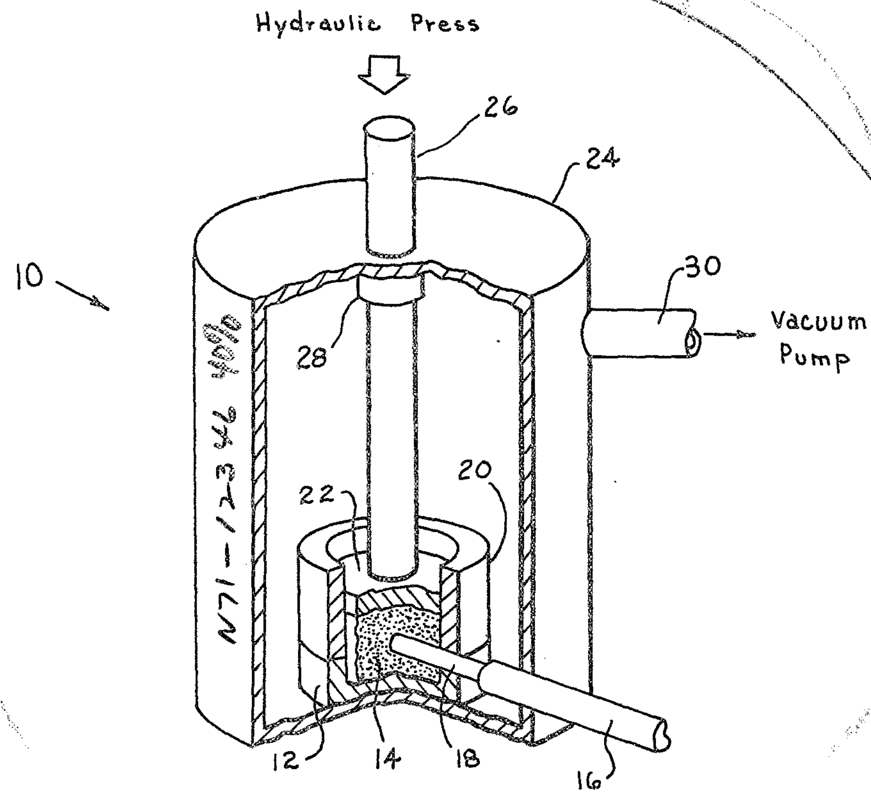

Fig 1

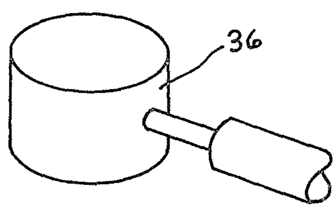

Fig 2

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United States Patent Office 3,490,440
Patented Jan. 20, 1970

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3,490,440
PRESSED DISC TYPE SENSING ELECTRODES WITH ION-SCREENING MEANS

Benjamin Mosier and Joe L. Day, Houston, Tex., assignors to the United States of America as represented by the Administrator of the National Aeronautics and Space Administration

Filed Jan. 5, 1967, Ser. No. 607,461
Int. Cl. A61b *5/05*; H01b *1/02*
U.S. Cl. 128—2.1 9 Claims

ABSTRACT OF THE DISCLOSURE

In biopotential electrodes made of silver, the preferred embodiment including an intimate mixture of silver, silver salt, and ion screening means comprising a colloidal material which are intimately mixed and pressed to form an electrode having improved characteristics.

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under an NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 435; 42 U.S.C. 2457).

SUMMARY OF PROBLEM AND SOLUTION

Primary requirements in biopotential electrodes include relative comfort for the observed subject, minimum skin-electrode junction resistance, and minimum skin electrode junction potential. An important additional factor is the requirement that piopotential electrodes maintain reliable data output during long monitoring experiments which requires that chemical poisoning of the electrode be held to a minimum. By chemical poisoning, reference is made to the fact that the electrode is customarily attached to the skin of the subject and the electrode is sometimes poisoned by the products of perspiration from the skin of the subject. The products of perspiration typically include simple salts which ionize relatively easy, and complex protein molecules which are substantially large and which do not ionize easily. The above-noted requirements have been dealt with in a less satisfactory manner in times past, and the apparatus of the prior art have been generally found wanting.

It is common to refer to the calomel electrode which is considered to be an industry standard. The present invention compares very favorably with the standard calomel electrode in numerous regards as will be noted. For instance, stability of the junction potential is substantially better than that of the calomel standard electrode over relatively short or long test periods. Also, long-term poisoning effects are substantially improved by the persent invention. With the problems of the prior art in view, and as indicated by specifications hereof, the preferred embodiment is summarized as providing a pressed electrode formed of intimately commingled powders of relatively small size in which silver, silver halogen salt, and a colloidal material comprising an ion screening means are pressed to form the pressed electrode of the present invention.

Therefore, an object of the present invention is to provide a new and improved pressed disc electrode provided with ion screen means for excluding large protein molecules from the electrode to prevent poisoning effects.

Another object of the present invention is to provide a new and improved pressed electrode for biopotential applications wherein movement of ions is permitted by ion screening means to communicate the electrical signal from the skin to the electrode.

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Another object of the present invention is to provide a new and improved biopotential electrode in which junction resistance and junction potential between the skin and the electrode are materially altered to permit passage of the biopotential signal with minimum noise from the electrode.

Other objects and advantages of the present invention will become more readily apparent from a consideration of the following specification and drawings wherein:

FIGURE 1 is an isometric view of means for forming the electrode of the present invention with a section broken away; and

FIGURE 2 is the completed electrode of the persent invention.

Considering the invention in detail, attention is first directed to FIG. 1 of the drawings which illustrates apparatus for forming the biopotential electrode of the present invention. In FIG. 1, the forming apparatus is indicated generally at **10** and includes a lower die piece **12** for preferably receiving silver, silver chloride, and colloidal material therein as indicated at **14**. The material **14** is granulated and is placed in the die piece **12** as will be described in greater detail hereinafter. The finished electrode requires electrical connection to monitoring apparatus, and to this end, an electrode wire **16** having a bared conductor **18** is positioned as illustrated in FIG. 1 whereby the conductor **18** is intimately associated with the interior of the completed biopotential electrode. The wire **18** is joined to the electrode by the pressing technique which will be described in greater detail hereinafter.

The upper portions of the mold are completed by the die piece **20** which mates with the piece **12** to provide a generally cylindrical chamber for receiving the granulated material **14** therein. At the seam between the pieces **12** and **20**, a hole is provided of appropriate diameter for receiving the electrical conductor **18** therein. A slidable pressure plate **22** is received within the bore of the assembled mold and is adapted to impart substantial pressures to the powdered, granulated material **14** in the mold. The pressure plate **22** is moved longitudinally of the bore in response to urging of apparatus which will be described.

Of particular interest to the present invention is the combination of silver and silver chloride serving as the conducting metal and halogen salt of the electrode. Silver chloride is quite active chemically, and to this end, the mold is made of non-corrosive materials. By way of example, Teflon, nylon or zirconium are non-corrosive materials which do not suffer from close, intimate contact with the silver chloride. Moreover, the use of nylon or Teflon, at least to the extent of lining the mold dies, enables separation of the completed pressed electrode which is easily freed from the die after compression. In this regard, the die pieces are formed of heavy guage metal to provide substantial strength to the mold and the pieces are plated or lined with the above noted non-corrosive materials.

Attention is re-directed to FIG. 1 which illustrates a vacuum chamber **24** surrounding the mold in which the electrode is assembled. The vacuum chamber **24** is of substantial size and is quite adequate if it accommodates the mold therein in somewhat the manner shown in FIG. 1. Of course, the vacuum chamber **24** fully encompasses the mold to enable a vacuum to be maintained about the particle materials in the chamber for purposes to be noted. While the mold is located within the vacuum chamber **24**, the apparatus for providing a compressive force to the material **14** is preferably located exteriorly of the vacuum chamber **24**, and to this end, a plunger or movable piston **26** is included for communicating a compressive force to the mold to compact the particles **14** into a solid electrode. The shaft or piston **26** passes through the vacuum chamber **24** by means of a packing gland **28** or

other appropriate means for maintaining the vacuum within the chamber **24**. An axial force is applied to the upper end of the piston **26** whereby the force is communicated to the pressure plate **22** for compacting the particles **14** in the mold.

Of course, conventional hydraulic apparatus can be used for applying the axial load to the shaft **26**. That is, a hydraulic press or other equivalent means provides a force having an equivalent pressure of about 8,000 to 50,000 pounds per square inch on the electrode material **14**.

A vacuum conduit **30** communicates the vacuum chamber **24** with a vacuum pump (not shown) for evacuating the chamber **24**. The vacuum pump is of conventional construction for substantially evacuating the chamber **24**. It has been discovered that the silver and salt mixture placed in the mold tends to absorb water and dissolved gases. The finished biopotential electrode usually suffers due to the inclusion of these extraneous materials in the finished product. The use of the evacuated chamber **24** draws the dissolved gas and water from the granulated materials **14**. An acceptable level of vacuum is evacuation to approximately one to five millimeters of mercury.

In considering operation of the vacuum on the granulated particles **14**, it should be noted that the fit of the pressure plate **22** within the mold piece **20** has some tolerance to permit escape of dissolved gases or water in the particles **14** within the mold. Contrariwise, if the pressure plate **22** sealed the mold perfectly, it would be impossible to remove water from the granulated particles **14** by the use of the vacuum pump and technique above noted.

To this end, nominal clearance is provided between the pressure plate **22** and the surrounding mold even at the expense of a few particles of granulated material escaping from the mold when pressure is applied.

Attention is directed to FIG. 2 of the drawings which illustrates the completed or finished electrode **36**. The electrode is finished after evacuating the chamber **24** and thereafter applying pressure having an equivalent pressure of approximately 8,000 to 50,000 pounds per square inch on the electrode material **14**. Pressure is maintained on the granulated materials for an interval of time of approximately one to three minutes. Moreover, the completed electrode **36** is prepared for installation and use on a subject to obtain biopotential signals as in EKG's, EEG's, or the like.

The method of the present invention has been generally described hereinabove, but additional details are presently noted. Of interest is the fineness of the particles **14** placed in the mold and the effect of particles too large or too small on the completed electrode. For instance, the silver chloride should be ground to at least 200 mesh, since the smoothness of the finished pellet or electrode depends on the fineness of the silver chloride particles. As a matter of fact, 325 to 400 mesh silver chloride is commercially available and is recommended for high quality pallets. On the other hand, grinding too finely increases the propensity to absorb water into the granulated particles **14**. After the products have been ground, it is preferable to intimately mix the metal and metal halogen salt with further grinding. Reference is made to micropulverizer means as a means for substantially commingling the metal and metal salt. Use of micropulverizer means yields particles having a diameter of approximately ten microns. If possible, particles less than ten microns are quite acceptable to the extent that excessive water absorption is not encountered.

Attention is next directed to the preferred components of the present invention and percentages of the preferred embodiment. The preferred materials of the present invention include a mixture of approximately 90% silver and approximately ten percent silver chloride. The mixture may vary to include perhaps as little as four percent or five percent silver chloride to a preferred maximum of approximately twenty percent silver chloride. The other halogen salts of silver are quite acceptable, although the silver chloride is the preferred salt. Also, other conducting metals have been used experimentally, but silver is the preferred basic ingredient in the biopotential electrode.

Added to the silver and silver chloride is a selected percentage of the colloidal material. The colloidal material provides the ion screening means in the completed electrode. The silver and silver salt preferably constitute about 90% of the mixture, and the colloidal material the other ten percent. Again, the colloidal material can vary over a range of perhaps five percent to fifteen percent.

The colloidial material is preferably selected from two groups described in detail below. Of particular interest is the group which is best denoted as plant hydrocolloids. Natural plant hydrocolloids are commonly water soluble gums or stabilizers which are generally carbohydrates derived from plant sources. Chemically, the plant hydrocolloids are usually polysaccharides or salts of polysaccharides. Their common properties include the formation of viscose solutions, or more accurately, colloidal sols or gels in water. In electrodes, common characteristics generally are the ability to improve the body, convey elasticity and texture, impart emollient properties, and stabilize the completed electrode of the present invention. Several plant hydrocolloids will be noted hereinbelow.

Guar gum is a straight chain mannon branched at regular intervals with a single membered galactose units or alternate mannose units. The long straight chain of this molecule, combined with its regular side branching, is unique among the natural colloids and should be beneficial as an ion-exchange material to be incorporated in the biopotential electrode. The molecular weight is in the area of 220,000. Agar-agar is a plant hydrocolloid which is generally insoluble in cold water, and is also a completely reversable hydrocolloid. Agar-agar is believed to be a linear polygalactose sulfuric ester. It seems likely that agar-agar is a calcium polygalactopyranose complex. Basic constituents seem to include calcium, magnesium, sodium, and potassium.

Gum arabic is a complex mixture of calcium, magnesium and potassium salt of arabic acid. Arabic acid is a complex of galactose, rhamnose, arabinose, and glucosonic acid. The molecular weight of gum arabic is on the order of about 240,000.

Gum tragacanth is a soluble portion tragacanthen and includes an insoluble portion, borsorin, wherein the borsorin is approximately sixty to seventy percent of the total volume by weight. Tragacanthen comprises a ring containing three molecules glucosonic acid and one molecule arabinose with a side chain of two molecules or arabinose. Gum tragacanth apparently contains small amounts of cellulose starch and protein substances.

Gum ghatti is amphorous translucent water soluble complex polysaccharide. It has good film forming properties and is a good binder for silver-silver chloride electrodes.

Locust bean gum is a polysaccharide built up of a main chain of mannose units with short branching single galactose units. The molecular weight is about 310,000.

Gum karaya is a complete polysaccharide of high molecular weight perhaps on the order of 9,500,000. On hydrolysis it yields galactose, rhamnose and galactorinic.

An additional class of colloidal materials may be generally described as clay or clay like materials which customarily include substantial quantities of aluminum silicates. One such material is bentonite clay which is commercially sold under the trade name Zeogel. The Zeogel product is a modified montmorillanite which yields substantial stability and minimum resistivity in the completed electrode for a substantial period of time. An additional clay or clay like product is Veegum, which is generally an isomorphous silicate which also gives a very stable and sensitive electrode.

The foregoing examples of the colloidal material indicate the operation of the ion screening means in the

electrode. When the colloidal material is added to the silver and silver salt, and the electrode is formed in the hydraulic press, the dispersion of the ion screening means throughout the electrode provides a means whereby selective ion movement is permitted into and out of the electrode. In the conventional installation of the electrode, the electrode is placed adjacent the skin of a subject to obtain biopotential signals therefrom. Such placement enables the electrode to obtain signals from the skin by means of ion interchange therebetween. In long term monitoring applications, the great likelihood is that the subject will perspire to a greater or lesser extent at the skin. This places additional ions between the skin and the electrode which complicate the chemistry of the junction. The complicating factors result from a multitude of reasons. For instance, the products of perspiration generally include relatively simple salts which ionize easily and provide additional ion carriers for the current between the skin and the electrode. The ion screening means of the present invention permits the current to flow to the electrode without limiting the current or without increasing the ohmic resistance of the skin-electrode junction. Also, the products of perspiration include complex protein molecules which are detrimental in two regards. In the first instance, the protein molecules are substantially large and generally tend to block the pores of the electrode. Secondly, and of greater importance, is the fact that that large protein molecules combine to form nonionizing compounds in the electrode which provide a long term poisoning effect. The ion screening means of the present invention prevents the large protein molecules from chemical interaction with the electrode and therefore prevents the poisoning effect. Also, the ion screening means of the present invention seems to lower the skin-junction electrode resistance and potential.

While the foregoing describes the preferred embodiment of the present invention, the scope thereof is defined by the appended claims.

What is claimed is:

1. In biopotential electrodes of the pressed disc types

including a metal which is a good conductor and a halogen salt of the metal for providing ionic electrical conduction of signals to the electrodes, the improvement comprising ion selective means dispersed in the electrode which comprises a colloidal material.

2. The invention of claim 1 wherein said colloidal material is a polysaccharide or a salt thereof.

3. The invention of claim 2 wherein said colloidal material is selected from the group consisting of guar gum, agar-agar, gum arabic, gum tragacanth, gum ghatti, locust bean gum, or gum karaya.

4. The invention of claim 1 wherein said colloidal material is a clay or claylike material.

5. The invention of claim 4 wherein said colloidal material is composed principally of aluminum silicates.

6. The invention of claim 1 wherein said electrode is formed principally of silver and silver chloride, and wherein said silver chloride does not exceed approximately 15% of said electrode.

7. The invention of claim 6 wherein said silver chloride has a particle size of approximately ten microns or less, and is combined with silver particles and pressed to shape.

8. The invention of claim 1 wherein said metal and halogen salt are silver and silver chloride having particle sizes of approximately ten microns, and which are thoroughly commingled.

9. The invention of claim 1 wherein said metal and halogen salt are silver and silver salt which comprise approximately 90% of said electrode by weight.

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WILLIAM E. KAMM, Primary Examiner

U.S. Cl. X.R.

252—514